

**OMI Science Team Meeting
Goddard Space Flight Center (GSFC)
September 12th – 14th, 2017**

**Mission Operations Working Group (MOWG)
Report to the OMI Science Team**

**Presented by Dominic M. Fisher,
Aura Mission Director (GSFC – ESMO - Code 428/584)**

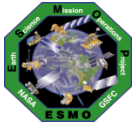
dominic.m.fisher@nasa.gov



Aura Mission Operations Working Group (MOWG)

The MOWG, established in 1997, is dedicated to ensuring the health and safety of the Aura satellite (spacecraft bus and instruments) to enable science observations.

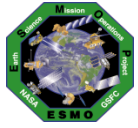
20 years of collaboration between the various Ops teams!



2017 OMI IOT / FOT MOWG Meeting



<u>Name</u>	<u>Affiliation</u>
Dominic Fisher	Aura MD / ESMO / GSFC
Bill Guit	Aqua MD / ESMO / GSFC
Lindsai Bland	EOS FOT Mgr / EOS / GSFC
Chuck Hudson	Aura FSM / EOS / GSFC
Jacob Williams	Aura Inst / EOS / GSFC
Tim Russell	Aura CDH / EOS / GSFC
Sam Lewis	Aura GNC / EOS / GSFC
Grant Barrett	Aura GNC / EOS / GSFC
Joshua Bowman	Aura GNC / EOS / GSFC
Mirna van Hoek	OMI Lead / KNMI
Mike Stoddard	OMI IAM Lead / NGAS

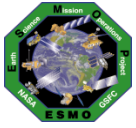


OMI IOT / FOT MOWG

Key Meeting Objectives



- **Discuss current Aura spacecraft and OMI instrument status**
- **Highlight any performance trends of note and project any impacts to continued OMI operations**
- **Identify any operational changes that may be needed to ensure continued OMI operations**
- **Express any concerns or potential process improvements (i.e., any interface / ground sys issues)**

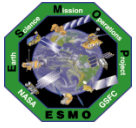


OMI IOT / FOT MOWG Meeting Agenda

(September 13, 2017)



Time	Topic	Presenter
02:00	Welcome / Introduction	Fisher / All
02:05	GSFC ESMO Update	Fisher
02:10	Aura Mission Status	Fisher
02:20	Aura Spacecraft / EOS Ground System Status	Hudson
02:30	OMI Instrument Status	Van Hoek
02:40	OMI IAM Status	Stoddard
02:50	Special Topics Discussion	All
	<ul style="list-style-type: none">• Survival Transition Recovery plans• White Light Source Degradation• Solar Calibration Measurement Constraints• Inclination Adjust Maneuvers using RWs• Retrograde Maneuvers	
03:50	Summary / Review Actions	All



OMI IOT / FOT MOWG Meeting Detailed Agenda

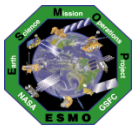


GSFC ESMO Update

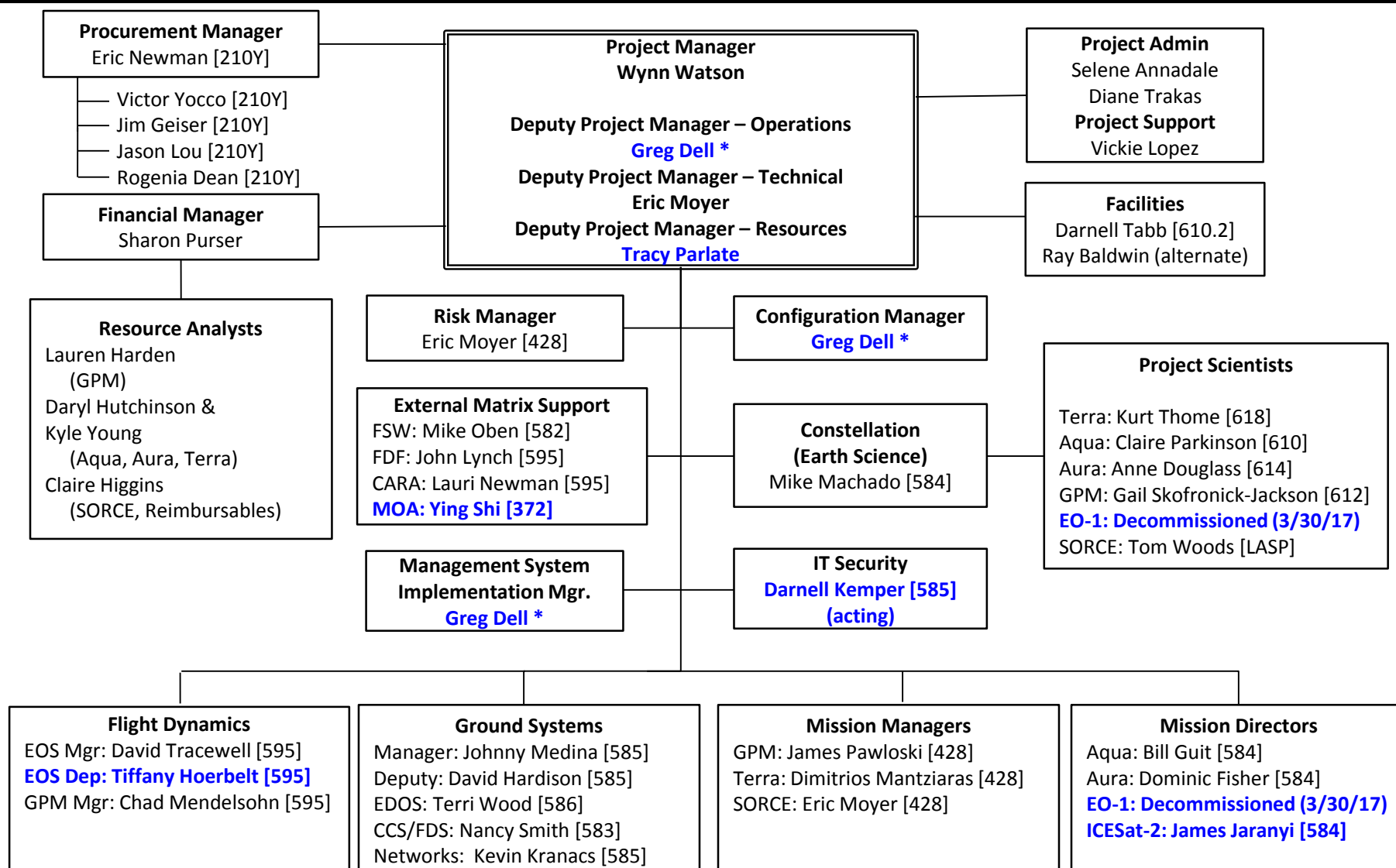
ESMO Organization	Fisher
2017 Senior Review	

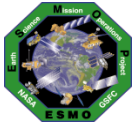
Aura Mission Status

Mission Summary	Fisher
Spacecraft Subsystem Summary	
Recent Activities	
Planned Activities	
Overall Summary	
Additional Slides – Spacecraft Maneuvers, Ground Track, HIEs, Data Capture, & Ops Error Stats	



ESMO Organization



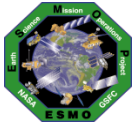


Aura's 13th Anniversary!



**Launch Date:
July 15, 2004**





Aura Spacecraft Subsystems

(Changes since Sept 2016 MOWG @ Rotterdam)



- **Command & Data Handling (CDH) – Nominal**
 - *Solid State Recorder (SSR) Anomaly (December 4-18, 2007)*
 - » Initial symptoms occurred December 4-18, 2007
 - » **Newest symptoms started in January 2017 and remain active (impacting S-Band HK data capture)**
- **Communications (COMM) – Nominal**
- **Electrical Power System (EPS) – Nominal**
 - *Array Regulator Electronics (ARE) Anomalies:*
 - » *Solar Panel Connector Anomaly – ARE-3C (January 12, 2005) – loss of ~11 strings*
 - » *MMOD Strike – ARE-5A (March 12, 2010 & April 25, 2013) – loss of ~6 strings*
 - *ARE Degradation due to aging – each occurrence is loss of ~ 1 string:*
ARE-5C (9/27/12, 2/4/13), ARE-1A (3/12/10, 11/5/11), ARE-6A (9/14/13), ARE-4A (12/8/14), ARE-1C (7/14/17)
 - » ***Estimated that Aura has lost 25 strings of solar cells out of a total of 132 strings (~18.9%)***
 - » ***Aura continues to have significant power margin where the life limiting item is fuel***
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
 - ***Reaction Wheel Assembly (RWA) #3 Anomaly (12/03/2016) – Recovered on 12/13/16***
- **Propulsion (PROP) – Nominal**
- **Thermal Control System (TCS) – Nominal**

All subsystems configured to primary hardware

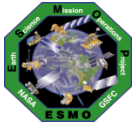


Summary of Activities

(Since Sept 2016 MOWG @ Rotterdam)

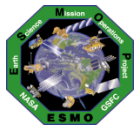


- **17 CARA High Interest Orbital Debris Events (Tiers 1-4) (As of 7/25/17)**
 - 8 required significant action (T3 / T4)
 - Tier 1 – Notify, Tier 2 – Briefing, Tier 3 – Plan, Tier 4 – Execute DAM or alter DMU
- **2 Spacecraft Bus Anomalies**
 - RWA #3 Spin-down (12/3/16) – recovered 12/13/16
 - FMU/SSR Anomaly – new symptoms since January 2017 – on-going
- **7 Instrument Anomalies**
 - MLS: R2 Phased Locked Loop (PLL) loss of lock – adjusted 3/08/17
 - OMI: 1 Instrument Survival Event (3/12/17) – recovered 3/16/17
 - TES: 6 ICS Stalls (10/24/16, 2/5/17, 2/18/17, 2/26/17, 3/12/17, 7/29/17) – on-going
- **14 Spacecraft Maneuvers**
 - **10 Drag Make-up Maneuvers (DMUMs # 96 – 105)**
 - » (6) Routine: 09/23/16, 11/15/16, 12/15/16, 1/20/17, 6/21/17, 8/16/17
 - » (4) CA Impacted: 10/13/16 (replan), 3/26/17 (DAM), 5/3/17 & 7/21/17 (replan)
 - **4 Inclination Adjust Maneuvers (IAMs # 49 – 52)**
 - » 3/2/17, 3/9/17, 3/23/17, 3/30/17
- **1 Instrument Calibration Maneuvers**
 - **MLS Yaw & Moon Scan #12 (3/14/17) (GSFC Code Red – FOT support remotely)**



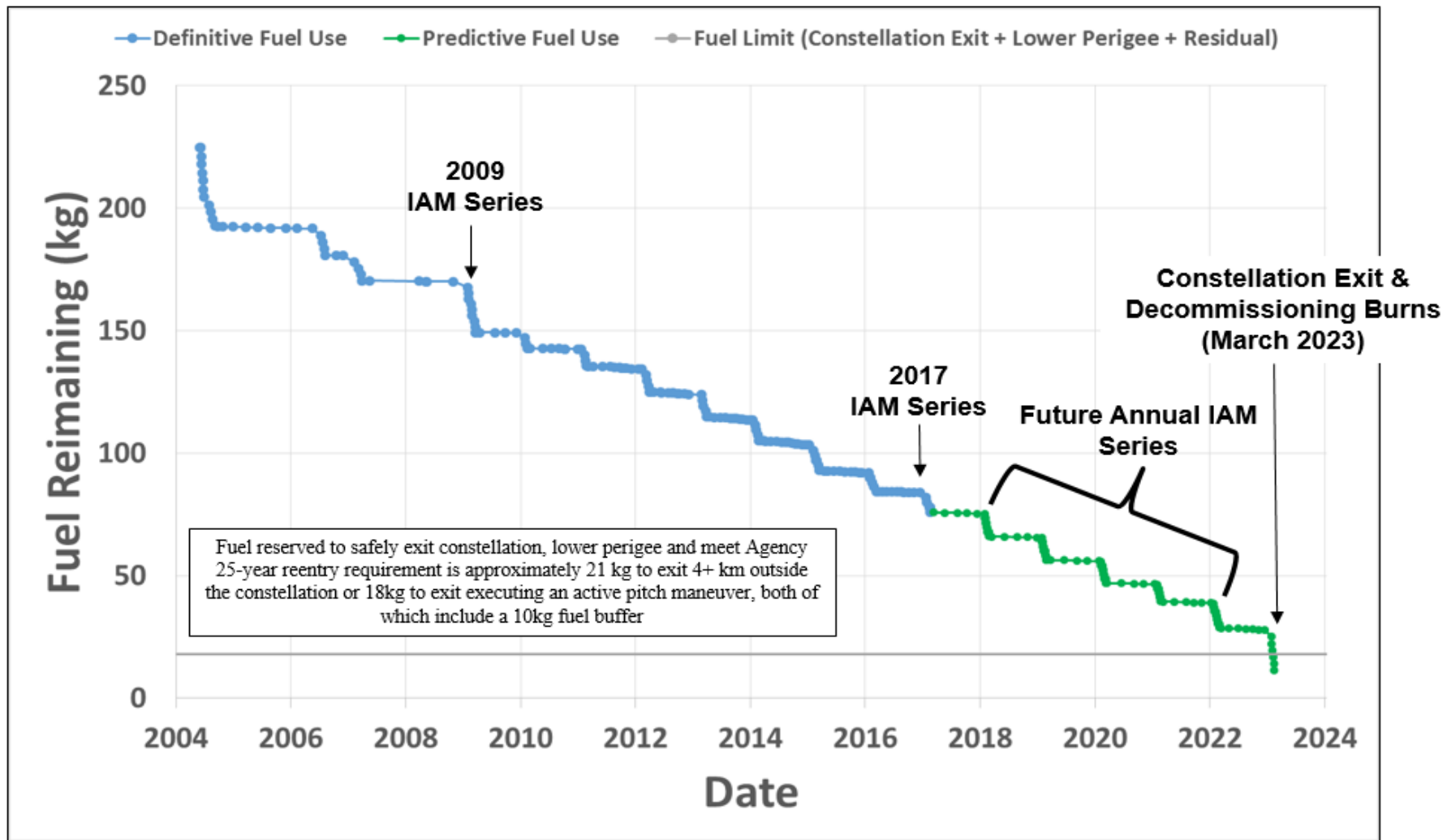
Planned Activities

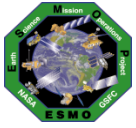
- **September 2017: OMI Science Team Meeting**
- **December 2017: Earth Science Constellation (ESC) MOWG (12/5-7 / @ NASA KSC)**
 - Update propellant budget, decommissioning analysis, reliability predictions,...
- **January 2018: ESMO Annual Review #11**
- **Spring 2018: Annual Inclination Adjust Maneuvers (DRAFT SCHEDULE)**
 - 2/28/18 (#53), 3/7/18 (#54), 3/14/18 (#55), 3/28/18 (#56), & 4/11/18 (#57)
- **April 2018: Draft Aura Decommissioning Review**
 - Document Phase F spacecraft activities, any new products to be developed for SC / Inst Calibration, proposed Engineering Tests, and Passivation Sequence
- **Summer 2018: Aura Science Team Meeting (Location TBD)**
- **Mid-to-Long-Term Plans**
 - **Continue to improve RMM / DAM execution**
 - » CA automation (CRMS) development
 - **Aqua/Aura Maneuver Working Group**
 - » Develop retrograde maneuver capability and explore any fuel saving options (IAM w/ RWs)
 - **EOS Automation (EA) – automation of routine operations**
 - » Phase II (Monitoring / Alerting) ORR – July 2017; Phase III - TBD



Fuel Usage: Actual & Predicted

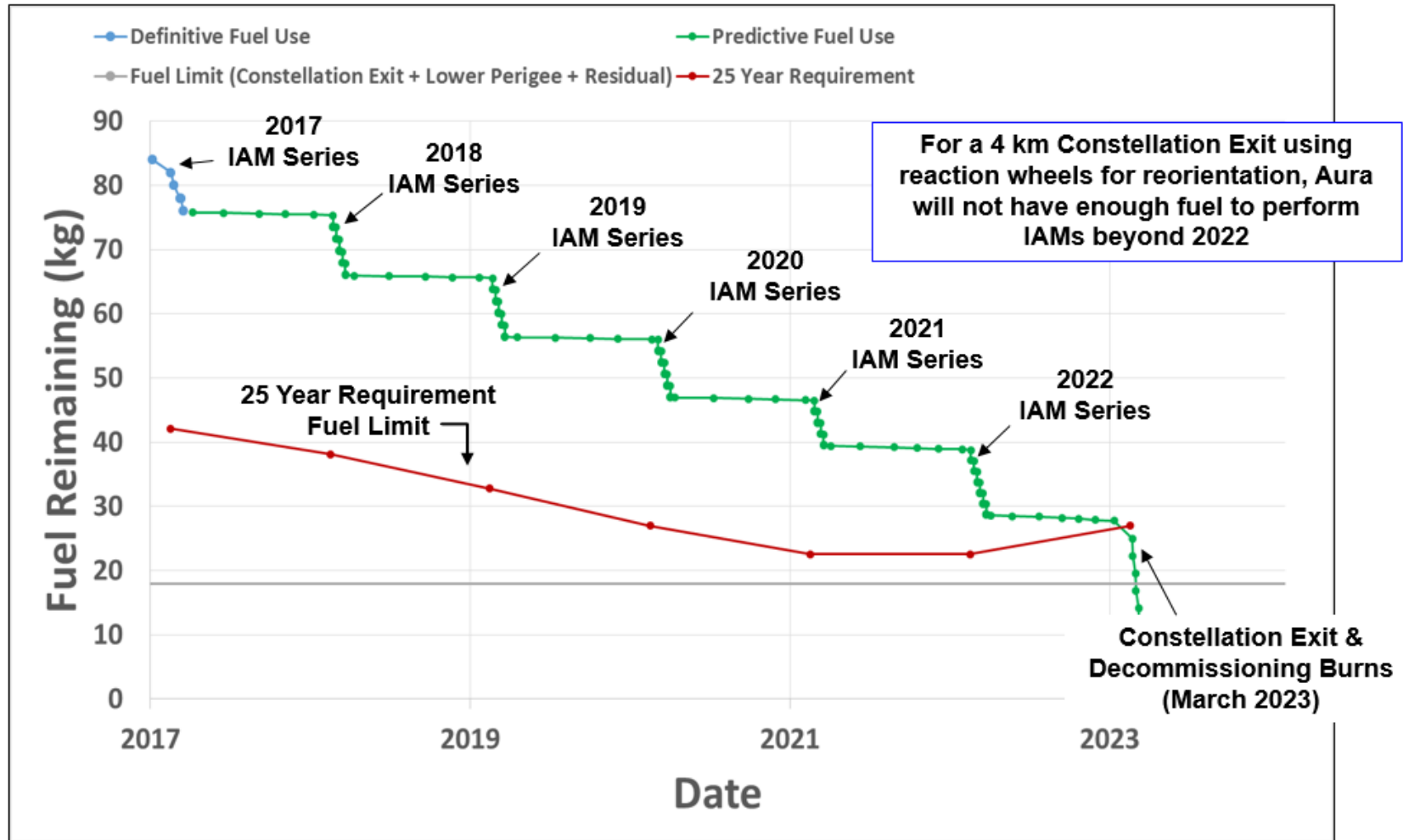
(Updated December 2016)

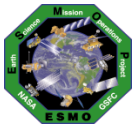




Aura DAS End of Life Predictions

(Updated December 2016)





Summary



- **Spacecraft Status - GREEN**
- **Instrument Status - GREEN**
 - HIRDLS: Chopper Stalled 03/17/08 – Not collecting science data
 - MLS: Operating Normally – Only periodic Band 13 measurements
 - » THz module (Standby Mode) – Expect one final set of measurements – TBD date
 - » 08/06/2013: Band 12 Shut down (reached end of useful life – 2-year design)
 - » 02/25/2017: R2 Lock Status Yellow Alarms (due to aging, voltage fine-tuned 03/08/17)
 - OMI: Operating Normally
 - » Field-of-View Anomaly started in September 2007 – currently stable
 - » 03/12/2017: OMI Survival Mode Transition (Recovered 03/16/17)
 - TES: Budget reductions driving decommissioning at end of FY17
 - » ICS Stalls (#11 - #16): 10/24/16, 02/05/17, 02/18/17, 02/26/17, 03/12/17, 07/29/17
 - » 09/20/2016: TES Safe Mode Event (Recovered 9/22/16)
- **Data Capture/L0 Processing Status – GREEN**
 - SSR Data Capture to 07/31/2017: 99.99579749%
- **Ground Systems –**
 - Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required
 - 04/11/2017: MMS Build 24.2.0 (RHEL7) Transition for Aura
 - 08/03/2017: EOS Automation (EA) R2.7 ORR (Phase II)



Aura Spacecraft / EOS Ground System Status

	Overview	FOT
	2015 / 2016 Summary (Status, Statistics, Special Activities, Maneuvers, Anomalies)	
	Spacecraft Risk Matrix	
	Aura FOT Staffing	
	Documentation (Ops Agreements, SOPs, Export Control Assessment, Senior Review)	
	Fault Management Readiness	
	Debris Avoidance Maneuvers Working Group	
	EOS Automation (Ground System)	



Flight Operations Team (FOT) Status



- Data Capture Rates continue to be stellar (+99.99%)
- No data losses or Ops Errors in +6 years
- Most spacecraft risks are stable with the exception of TES ICS stalls
- Operations Agreements are outdated, reviewing and updating with IOTs
- Drafting Instrument Safe / Survival SOPs, reviewing with IOTs
- FOT capturing routine instrument activities in standard operating procedures
- Export Control Assessment completed in Fall 2016
- Senior Review inputs completed in Spring 2017

Project Overview / Objective

EOS-Aura 2015 Summary

EOS-Aura 2016 Summary

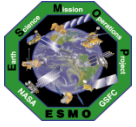
Aura 2015 Spacecraft Risk Matrix

Aura 2015 Spacecraft Risk Matrix Details

Position	Prime	Back-Up
FSM	Charles Hudson	Benee Durham
CDH	vacant	Jason Webber
COMM	Christopher Thompson	Christos Galatsatos**
EPS/TCS	Christos Galatsatos**	Samuel Lewis**
FSW	Cara Smith	Mike Cabrera
GNC	Samuel Lewis**	Samuel Lewis**
	Damien Roesler	Damien Roesler
	Joshua Bowman	Joshua Bowman
INST	Jacob Williams	Byron Graves

** Tri-Mission Certified

All positions have identified back-up ready to support on-call duties if required

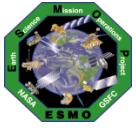


OMI IOT / FOT MOWG Meeting Detailed Agenda



OMI Status

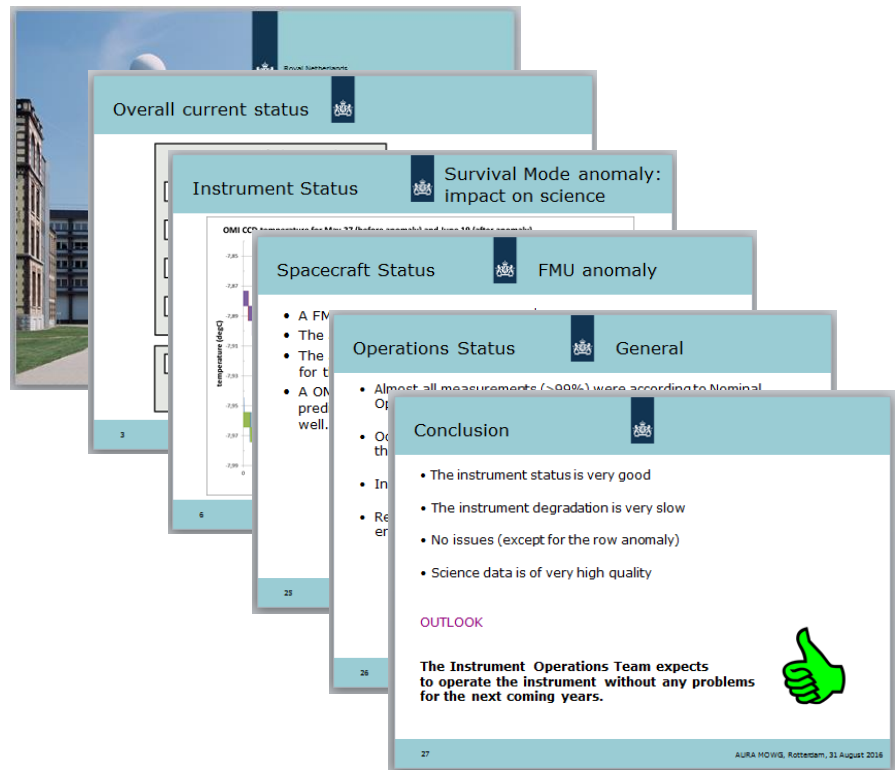
Instrument Status	OMI IOT
Spacecraft Status	
Operations Status	
Focus is on those items that can potentially impact the quality of the science data.	

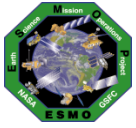


OMI Instrument Operations Team (IOT) Status



- There was 1 anomaly in 2017 that impacted the OMI science data (only 6 since launch):
 - OMI transition to Survival Mode on March 12, 2017: status solved
 - No remaining impact on science quality
- Instrument performs nominal (with exception of row anomaly)
- CCD temperatures still very stable (despite OMI to survival anomaly)
- All three mechanisms behave nominal
- Life limited items (mechanisms, internal calibration source) within budget
- Instrument degradation is very slow
- >99% of all measurements are according to Nominal Operations Baseline



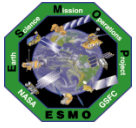


OMI IOT / FOT MOWG Meeting Action Items



Action Items Captured

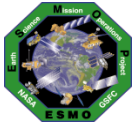
	Update OMI OA and constraint database (for rescheduling within 6 vs. 3 orbits)	IOT
	Draft Safe / Survival Mode Standard Operating Procedures (SOPs)	FOT / IOT
	FOT to share CCD trending data with IOT for further analysis	FOT / IOT
	Prepare for maneuver demonstration using reaction wheels (Fall 2017)	FOT / IOT



Summary

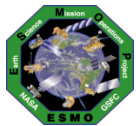


**The Mission Operations Teams
(spacecraft and instruments)
are dedicated to keeping Aura
operational as long as possible**



***Thank you for your attention.
Dank je wel
Kiitos***

Questions?



Abbreviations / Acronyms List

ARE –	Array Regulator Electronics	HIRDLS –	High Resolution Dynamics Limb Sounder	ORR –	Operational Readiness Review
CA –	Conjunction Assessment	HK -	Housekeeping	PROP -	Propulsion
CARA –	Conjunction Assessment Risk Analysis	HQ -	Headquarters	Pc –	Probability of Collision
CCD -	Charge Coupled Device	IAM –	Inclination Adjustment Maneuver or Interface Adapter Module	PLL –	Phased Locked Loop
CDH –	Command & Data Handling	ICS –	Interferometer Control System	R2 –	Receiver 2
COTS -	Commercial-off-the-Shelf	IOT -	Instrument Operations Team	RHEL –	Red Hat Enterprise Linux
CRMS –	Collision Risk Management System	IT -	Information Technology	RMM –	Risk Mitigation Maneuver
DAM –	Debris Avoidance Maneuver	kg -	kilogram	RW –	Reaction Wheel
DAS –	Debris Assessment Software	km –	kilometer	RWA –	Reaction Wheel Assembly
DMUM –	Drag Make-up Maneuver	KNMI -	Royal Netherlands Meteorological Institute	SC -	Spacecraft
EA –	EOS Automation	KSC -	Kennedy Space Center	SOP -	Standard Operating Procedure
EOS –	Earth Observing System	L0 –	Level-Zero	SSR –	Solid State Recorder
EPS –	Electrical Power System	MD -	Mission Director	TBD –	To Be Determined
ESC –	Earth Science Constellation	MLS –	Microwave Limb Sounder	TCS –	Thermal Control System
ESMO –	Earth Science Mission Operations	MMOD –	Micrometeorite Orbital Debris	TES –	Tropospheric Emissions Spectrometer
FDS –	Flight Dynamics System	MMS –	Mission Management System	THz -	Terahertz
FMU –	Formatter Multiplexer Unit	MOWG –	Mission Operations Working Group		
FOT –	Flight Operations Team	NASA –	National Aeronautics & Space Administration		
FSM -	Flight Systems Manager	NGAS -	Northrup Grumman Aerospace Systems		
FSW –	Flight Software	OA -	Operations Agreement		
FY –	Fiscal Year	OMI –	Ozone Monitoring Instrument		
GMT –	Greenwich Mean Time				
GNC –	Guidance Navigation & Control				
GSFC –	Goddard Space Flight Center				
HIE –	High Interest Event				